XXXVIII
IAH Congress

Groundwater Quality Sustainability
Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **360**

topic: **3**
Aquifer management

3.4
Environmental and artificial tracers in hydrogeology

title: **Groundwater flow system in the Nakano-shima Island, Japan, based on the spatial distribution of major components, CFCs, and 3H**

author(s): **Yukiko Kusano**
Department of Environment Systems, University of Tokyo, Japan,
kusano@geoenv.k.u-tokyo.ac.jp

Tomochika Tokunaga
Department of Environment Systems, University of Tokyo, Japan,
tokunaga@k.u-tokyo.ac.jp

Kazumi Asai
Geo-Science Laboratory Co. Ltd., Japan, asai@geolab.co.jp

Kazuyoshi Asai
Geo-Science Laboratory Co. Ltd., Japan, Kazuyoshi@geolab.co.jp

Katsuro Mogi
Department of System Innovation, University of Tokyo, Japan,
kmogi@sys.t.u-tokyo.ac.jp

Akio Matsuda
Ama Town Office, Japan, matsuda-akio@town.ama.shimane.jp

Satoshi Takizawa
Department of Urban Engineering, University of Tokyo, Japan,
takizawa@env.t.u-tokyo.ac.jp

keywords: island hydrology, fractured rocks, CFCs, ^{3}H, Japan

INTRODUCTION

Securing fresh water resources is vital for the human beings, and is especially critical at arid regions and isolated islands. Therefore, appropriate use and management of fresh water resources are critical issue for these areas, and it is necessary to understand the hydrological circulation for achieving sustainability of the society. This study attempts to reveal the groundwater flow system in the Nakano-shima Island, Japan, using major dissolved components, CFCs, and ^{3}H as tracers.

The Nakano-shima Island is situated in the Sea of Japan (Figure 1). The Oki–dozen Islands, one of which is the Nakano-shima Island, were formed by late Miocene (9-5 Ma) volcanism. The Islands are composed of somma, caldera, and central cone. The Nakano-shima Island is a portion of somma.

The Island is composed mostly of trachy-basalt and trachy-andesite rocks and partly of alkali olivine basalt lava (Figure 2) (Tiba et al., 2000). Fractures are frequently observed in basalt/andesite rocks, and groundwater exists manly in fractures (Tsukimori, 1984).

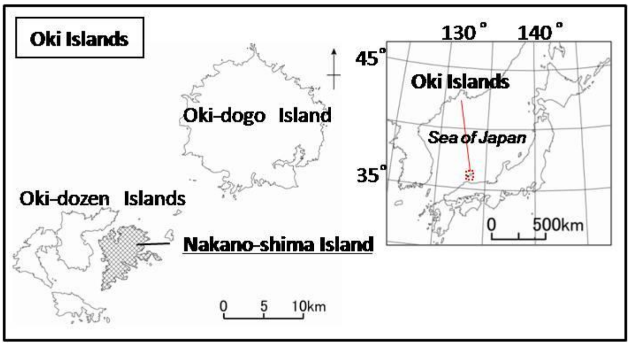

Figure 1. Location of the Nakano-shima Island.

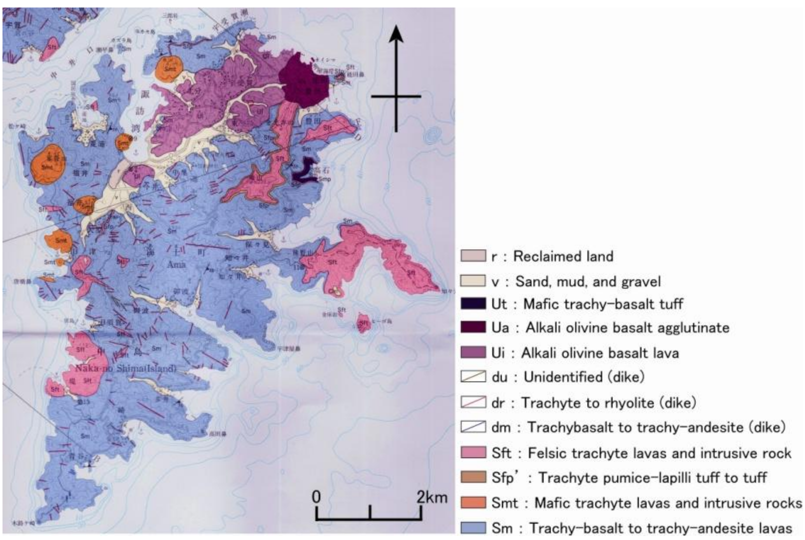

Figure 2. Geology of the Nakano-shima Island (Tiba et al., 2000).

METHODS

Water samples were taken from twelve deep wells, three shallow wells, six springs, and three surface streams in the Island in June and September 2009, and February 2010. Field parameters, including temperature, pH, electrical conductivity, dissolved oxygen concentrations, and oxidation-reduction potential were measured before sampling. All samples were analyzed for major dissolved components (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, SO_4^{2-}, NO_3^-). All groundwater samples were analyzed for CFCs, and several samples were also analyzed for ^3H.

RESULTS AND DISCUSSION

Samples obtained from surface streams, springs, and shallow wells show Na^+-Cl^- type (Figure 3). Water samples from springs and shallow wells showed higher concentrations of both Ca^{2+} and HCO_3^- compared with surface streams. Samples from deep wells tend to show Ca^{2+}-HCO_3^- type. Major dissolved components of surface water and shallow groundwater are considered to be influenced by sea salt because the Island is surrounded by the sea. Particularly, surface streams which have shorter residence time are strongly affected by the sea salt.

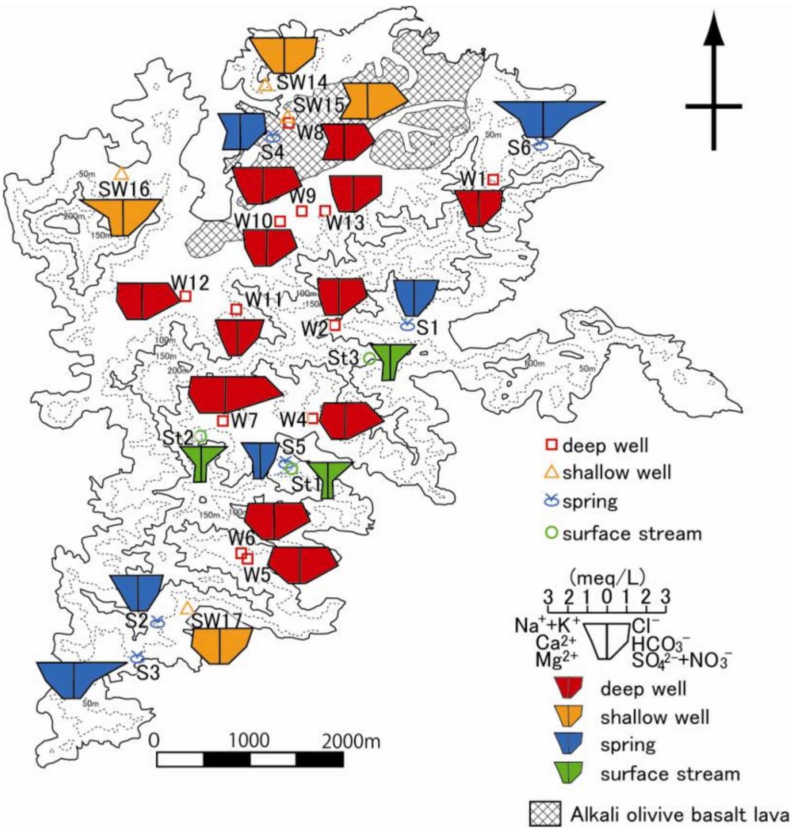

Figure 3. Major dissolved components of surface water and groundwater.

All samples obtained from the area covered by alkali olivine basalt lava showed Mg^{2+}-HCO_3^- type. Alkali olivine basalt lava contains higher MgO content compared with trachy-basalt and trachy-andesite rocks (Tiba et al, 2000). It is considered that groundwater with higher Mg^{2+} concentration described above is due to the water-rock interaction with alkali olivine basalt lava.

The correlations between the total amount of major dissolved components, bicarbonate, calcium, and magnesium concentrations, and the altitudes of springs and screen zones of wells were recognized, suggesting that groundwater of deeper part tends to have longer residence time (Figure 4).

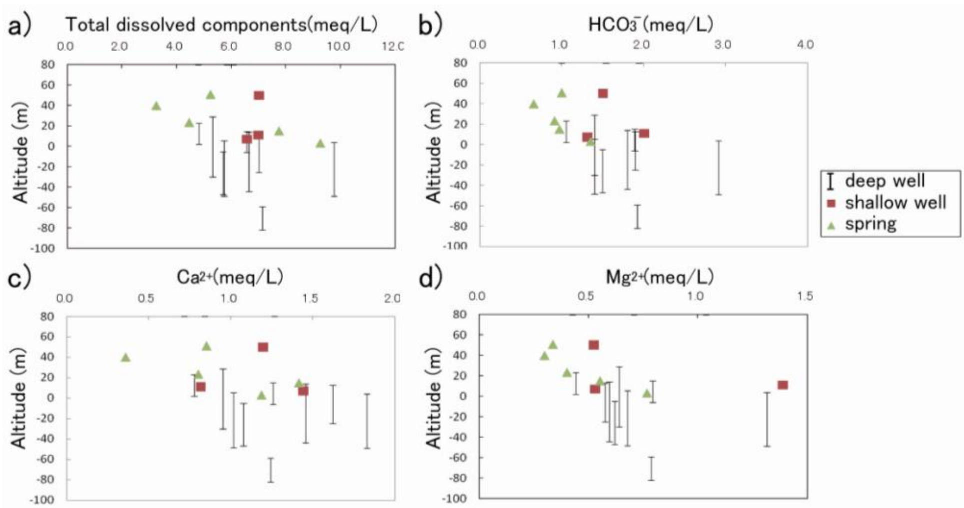

Figure 4. Relations between altitude and a) total major dissolved components, b) HCO_3^-, c) Ca^{2+}, and d) Mg^{2+}.

Water samples obtained from several wells showed that equivalent atmospheric concentrations of CFC-12 and CFC-11 were considerably higher than modern atmospheric concentrations. This result was considered to be due to the contamination by possible local CFCs sources, thus these data were not used for the discussion.

Good correlations between CFCs concentrations and ^3H concentrations were recognized (Figure 5). Also, negative correlations between both CFCs and ^3H concentrations and altitude of discharge of springs and screen zones of wells were found (Figure 6). These results suggest that deep groundwater tends to have longer residence time, which is consistent with the result obtained from major dissolved components.

^3H concentrations of two deep wells, W4 and W7, were 0.3 tritium unit (T.U.) and 0.6 T.U., respectively, much lower than other samples. CFCs concentrations of these samples were also lower, even though the altitude of the screen zone of W7 is similar with other deep wells. It suggests either the existence of groundwater flow system with longer residence time at least locally or the mixing with older/deeper water.

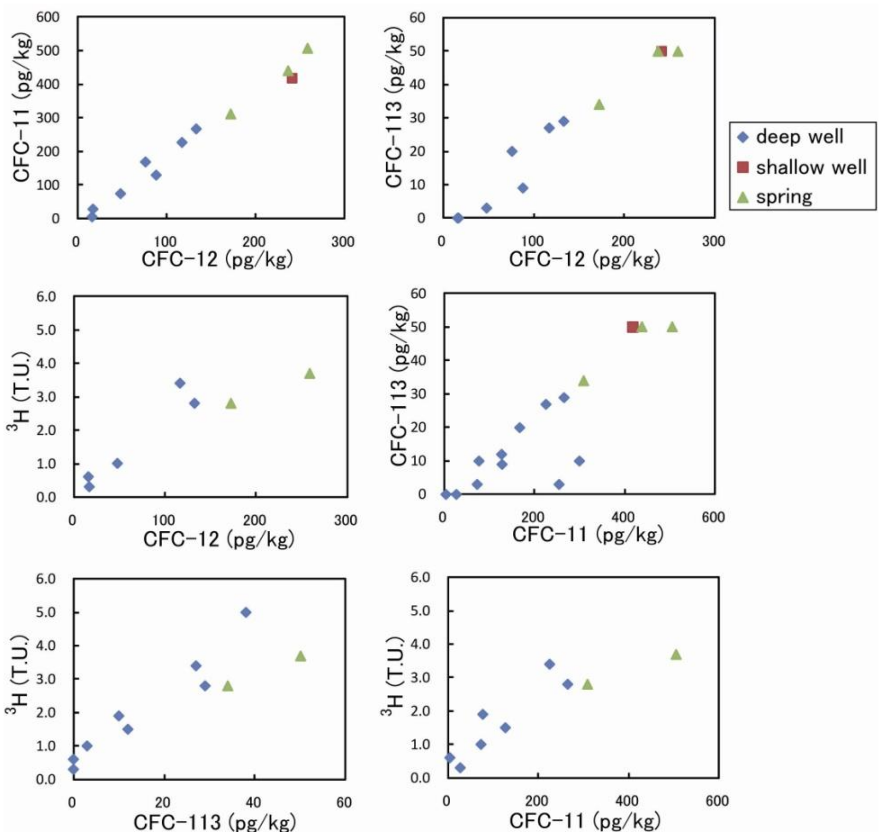

Figure 5. Concentrations of CFCs and ^3H of the groundwater samples.

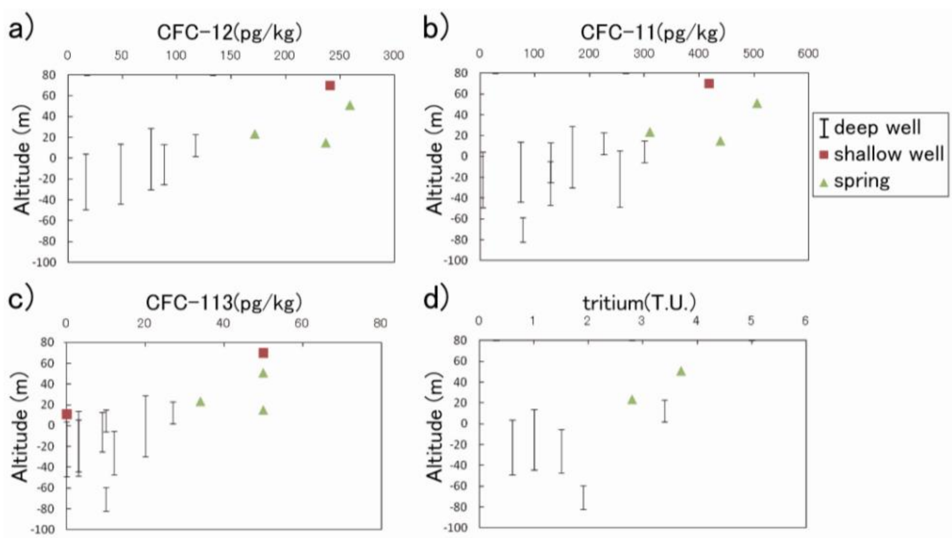

Figure 6. Relations between altitudes and a) CFC-12, b) CFC-11, c) CFC-113, and d) ^3H.

SUMMARY

Major dissolved components of shallow groundwater tend to show Na^{+}-Cl^{-} type. It is considered to be influenced by the sea salt. Deep groundwater tends to show Ca^{2+}-HCO_3^{-} type. Samples obtained from the area covered by alkali olivine basalt lava showed Mg^{2+}-HCO_3^{-} type, and it is considered to be due to the water-rock interaction. Relation between major components, CFCs, ^{3}H, and altitude suggests that deep groundwater tends to have longer residence time. Spatial distribution of CFCs and ^{3}H concentrations suggest the existence of the groundwater flow system with longer residence time at least locally or the mixing with older/deeper water.

REFERENCES

IAEA, 2006: *IAEA Guidebook on the Use of Chlorofluorocarbons in Hydrology*. Technical Report Series, No.438, 277p.

Tiba T., Kaneko N., Kano K., 2000: *Geology of the Urago District.* With Geological Sheet Map at 1:50,000, Geological Survey of Japan, 74p.

Tsukimori K., 1984: *Hydorogeology of Nakano-shima, Dozen, Oki Islands*. Geolgical Report of Shimane University. 3, pp. 161-165.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0